CLAIMS

We claim:

1. A process for carrying out gas-liquid countercurrent processing, comprising passing the liquid material and the gas reactant in countercurrent flow through the fixed bed of catalyst in a reactor, wherein the fixed bed of catalyst includes two or more catalyst layers, with the difference of voidages between the adjacent catalyst layers being at least 0.05.

2. The process of claim 1 wherein the bed of catalyst includes 2 to 10 catalyst layers.

3. The process of claim 1 wherein the difference of the voidages between the adjacent catalyst layers is 0.05 to 0.65.

4. The process of claim 3 wherein the difference of the voidages between the adjacent catalyst layers is 0.10 to 0.40.

5. The process of claim 1 wherein the voidage of catalyst layers is increased or decreased in the direction of the flow of the liquid phase.

6. The process of claim 1 wherein the voidages of the low-voidage catalyst layers are 0.25 to 0.55, and the voidages of the high-voidage catalyst layers are 0.35 to 0.90.

7. The process of claim 6 wherein the voidages of the low-voidage catalyst layers are 0.30 to 0.50, and the voidages of the high-voidage catalyst layers are 0.45 to 0.80.

8. The process of claim 1 wherein the low-voidage catalyst layers consist of catalysts in the form of sphere, cylinder, trefoil or quatrefoil.

9. The process of claim 1 wherein the high-voidage catalyst layers consist of catalysts in the form of ring, wheel, sphere with holes, or cylinder, trefoil or quatrefoil of large particle size.

10. The process of claim 9 wherein the high-voidage catalyst layers consist of catalyst of a single particle size or shape, or alternatively, consist of catalyst of a low void fraction and catalyst of a high void fraction and/or filler of a high void fraction mixed and loaded together.

11. The process of claim 1 wherein the catalyst is loaded in a random mode.

12. The process of claim 1 wherein the liquid feedstock is a diesel oil distillate, the gas reactant is hydrogen, and the catalyst bed in the reactor consists of a hydrotreating catalyst, with the voidges of the catalyst layers within the catalyst bed decreasing in the direction of the flow of the liquid phase.

13. The process of claim 12 wherein the catalyst bed includes two catalyst layers: a low-voidage layer at the lower section and a high-voidage layer at the upper section of the reactor, with the low-voidage layer constituting 20 to 90 % of the total volume of the catalyst bed.

14. The process of claim 13 wherein the low-voidage layer constitutes 30 to 80 % of the total volume of the catalyst bed.

15. The process of claim 12 wherein the low-voidage catalyst layer or layers consist of one or more catalysts selected from the group consisting of a catalyst comprising a metal from Group VIB and a metal from Group VIII of the Periodic Table of Elements in a reduced state, a catalyst comprising a noble metal, a catalyst comprising the nitride or sulfide of Mo-Ni-W, and a catalyst comprising the sulfides of

non-noble metals from Group VIB and a metal from Group VIII which shows little loss of sulfur in the reaction; the high-voidage catalyst layer or layers consist of a hydrorefining catalyst comprising a metal from Group VIB and a metal from Group VIII of the Periodic Table of Elements in a sulfurized form.

16. The process of claim 15 wherein the noble metal is Pt and /or Pd, the metal from Group VIB is Mo and/or W, the metal from Group VIII is Co and/or Ni, the support is a porous refractory inorganic oxide; the content of the noble metal is 0.05 to 5 % by weight, and the content of the non-noble metal is 10 to 40 % by weight, calculated as oxide.

17. The process of claim 12 wherein the reaction proceeds under reaction conditions of a reaction temperature between 240 to 427 ^{0}C, a reaction pressure between 1.0 to 20.0 MPa, a hydrogen/oil volume ratio of 50 to 1, 000, and a liquid volume hourly space velocity of 0.1 to 7.5 h^{-1}.

18. The process of claim 1 wherein the liquid raw material is monoalkyl maleate, the gas reactant is C1-C4 alkanol, and the catalyst bed consists of an esterification catalyst, with the voidage of the catalyst layers within the catalyst bed increasing in the direction of the flow of the liquid phase.

19. The process of claim 18 wherein the esterification catalyst is an acidic cation-exchange resin catalyst.

20. The process of claim 18 wherein the catalyst bed includes three catalyst layers.